



Lessons Learned from I/M Program Evaluation

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Inspection and Maintenance Programs
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by

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Outline

1. Evaluation using In-Program v. On-Road data
2. Results of evaluation of AZ IM240 program
3. Improvements to make evaluation easier
 - data improvements
 - program improvements
4. General issues for I/M evaluation
5. Summary of evaluation of CA ASM program
6. Using remote sensing data in program evaluation

1. Evaluation Using In-Program v. On-Road Emissions Data

- In-Program

- compare final to initial test result for individual vehicles
 - accounts only for vehicles reporting for testing
 - emissions measured under specific conditions
 - Fast Pass complicates analysis
 - passing vehicles tested only one time
- track vehicles over multiple I/M cycles

- Remote Sensing (and Roadside Pullover testing)

- compare emissions up to 3 months before I/M test with up to 3 months after I/M test
 - sample of all on-road vehicles, tested under varied loads
 - can compare measurements made under loads similar to those of the I/M test
- analyze trend in emissions as vehicles get closer to, and further from, I/M test
- identify vehicles that never receive a passing I/M test that continue to be driven in I/M area

Passing Vehicles Tested Only Once by Program

- Vehicle emissions are variable, for many reasons (Wenzel et al, 2000; Bishop et al, 1996; Knepper et al, 1993)
- Some high emitters have intermittent malfunctions, which cause them to fail one day but pass next (flippers)
 - some passing flippers would fail if retested
 - some failing flippers pass retest with no repairs being made
- I/M cutpoints are arbitrary
 - some marginally passing vehicles would fail if retested
 - some marginally failing vehicles pass retest with no repair
- Result: In-Program data over-estimate actual emissions reduction

2. Analysis of Arizona IM240 Program: Overview

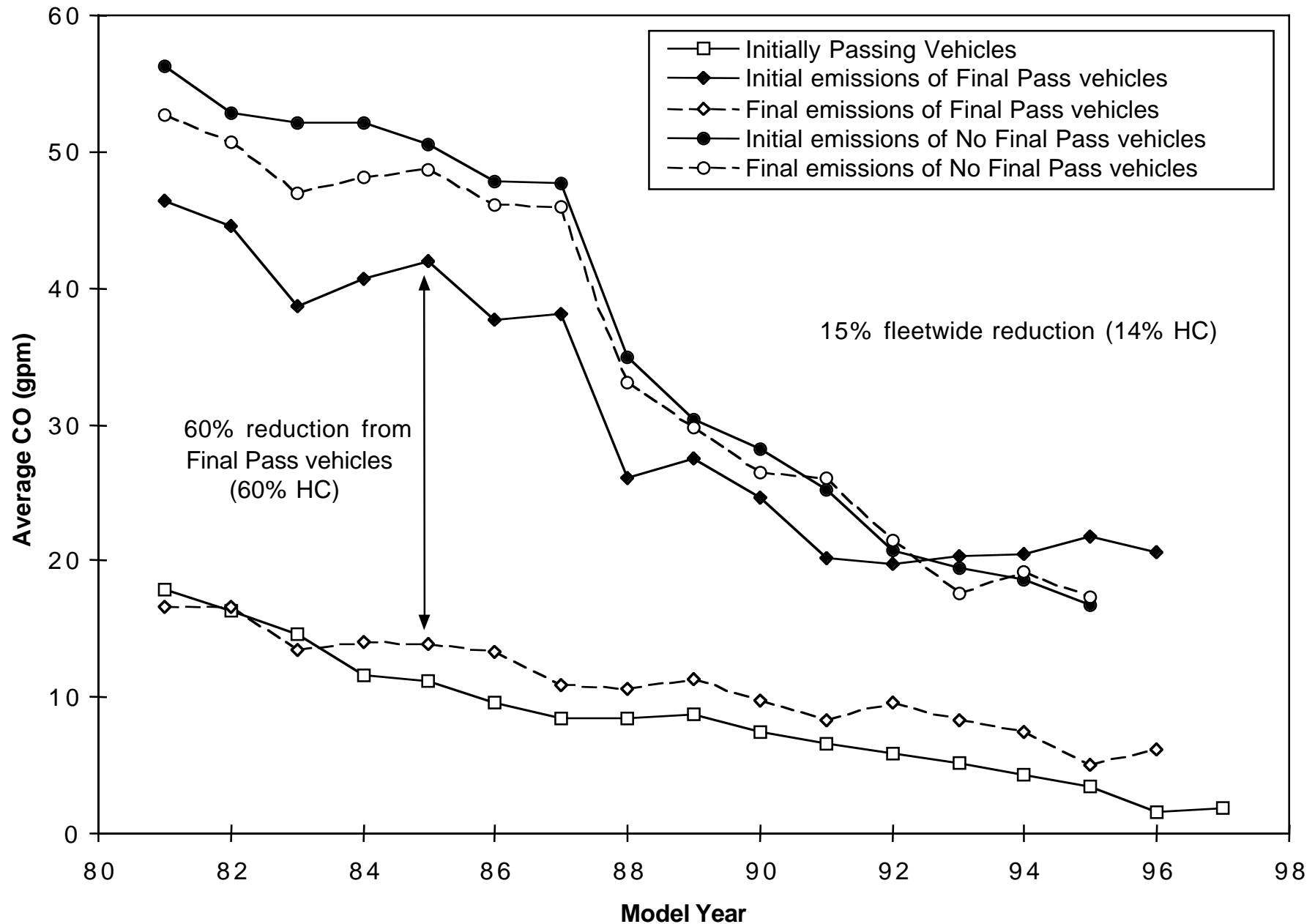
- Many vehicles take months to pass, or never pass, I/M test
- Many of these vehicles still driving in I/M area
- On average, repairs made to vehicles last about two years
- Large reduction in emissions immediately prior to initial I/M test
- Different analysis methods needed to understand different aspects of I/M programs

Analysis of Arizona IM240 Program: In-Program Data

- 1996-97 IM240 data compared with RSD data
 - 15% / 14% / 7% IM240 reduction in HC/CO/NO_x
 - HC, CO emissions of Final Pass vehicles reduced 60%
 - final emissions of Final Pass vehicles higher than emissions of Initially Passing vehicles
 - 33% of initial fails never receive passing test (4% waiver rate)
- Individual vehicles tracked over 2 I/M cycles (1995 and 1997)
 - 37% of Final Pass vehicles in 1995 fail initial 1997 test (44% for MY81, 14% for MY94)
 - 40% of repeat failures fail for same combination of pollutants
 - 40% of vehicles tested in 1995 do not report for testing in 1997; 50% of vehicles tested in 1997 not tested in 1995 (half of these were out of state or exempted in 1995)
 - 1995-only and 1997-only I/M fleets have higher initial emissions by MY than fleet tested in both years
 - Fleet emissions 1 year after final I/M test = final emissions

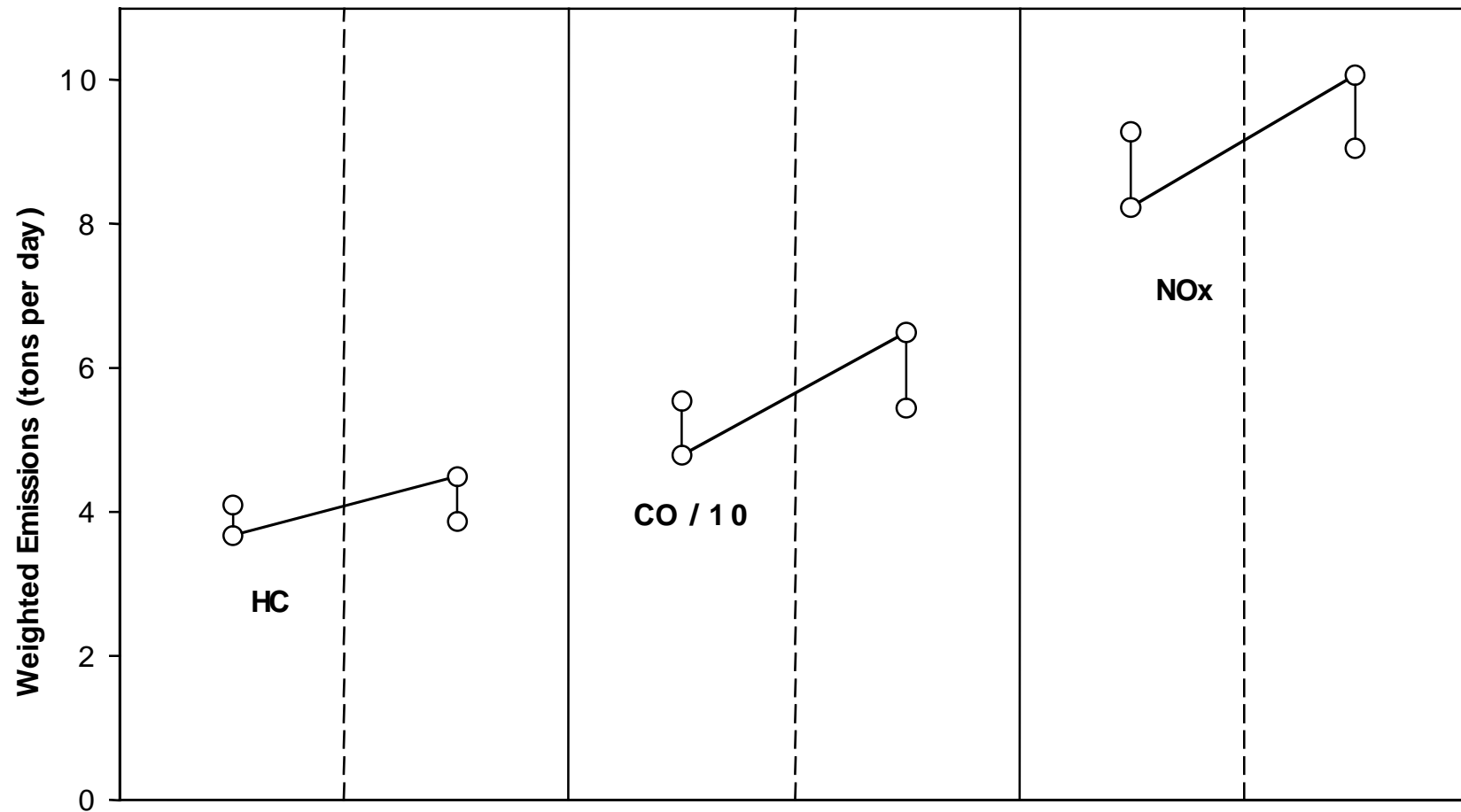
Average CO gpm by MY and I/M Result

1996-97 Arizona IM240



Fleet Emissions over Two I/M Cycles

Passenger Cars tested in both 1995 and 1997, Arizona IM240

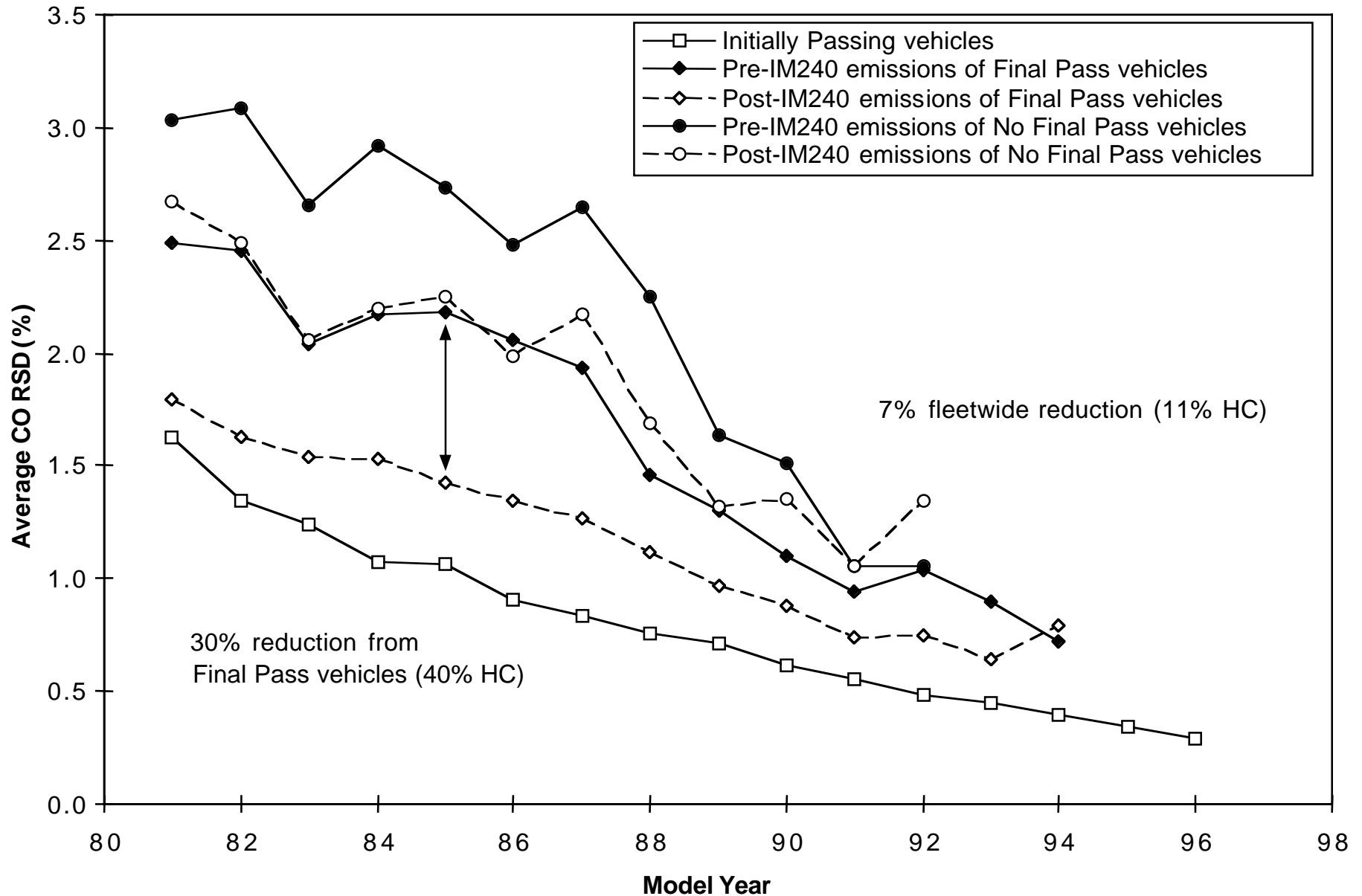


Analysis of Arizona IM240 Program: Remote Sensing Data

- 1996-97 IM240 data compared with RSD data
 - 1996-97 RSD indicate only 11% / 7% reduction in HC/CO
 - HC, CO emissions of Final Pass vehicles reduced only 30%
 - difference due to
 - vehicles measured under different loads
 - vehicles measured up to 3 months after final I/M test
- Average RSD emissions as vehicles get closer to, and further from, I/M test
 - program effectiveness decreases over time
 - fleet emissions reduced by 12% 3 weeks before initial I/M test
- RSD data used to identify No Final Pass vehicles still in area

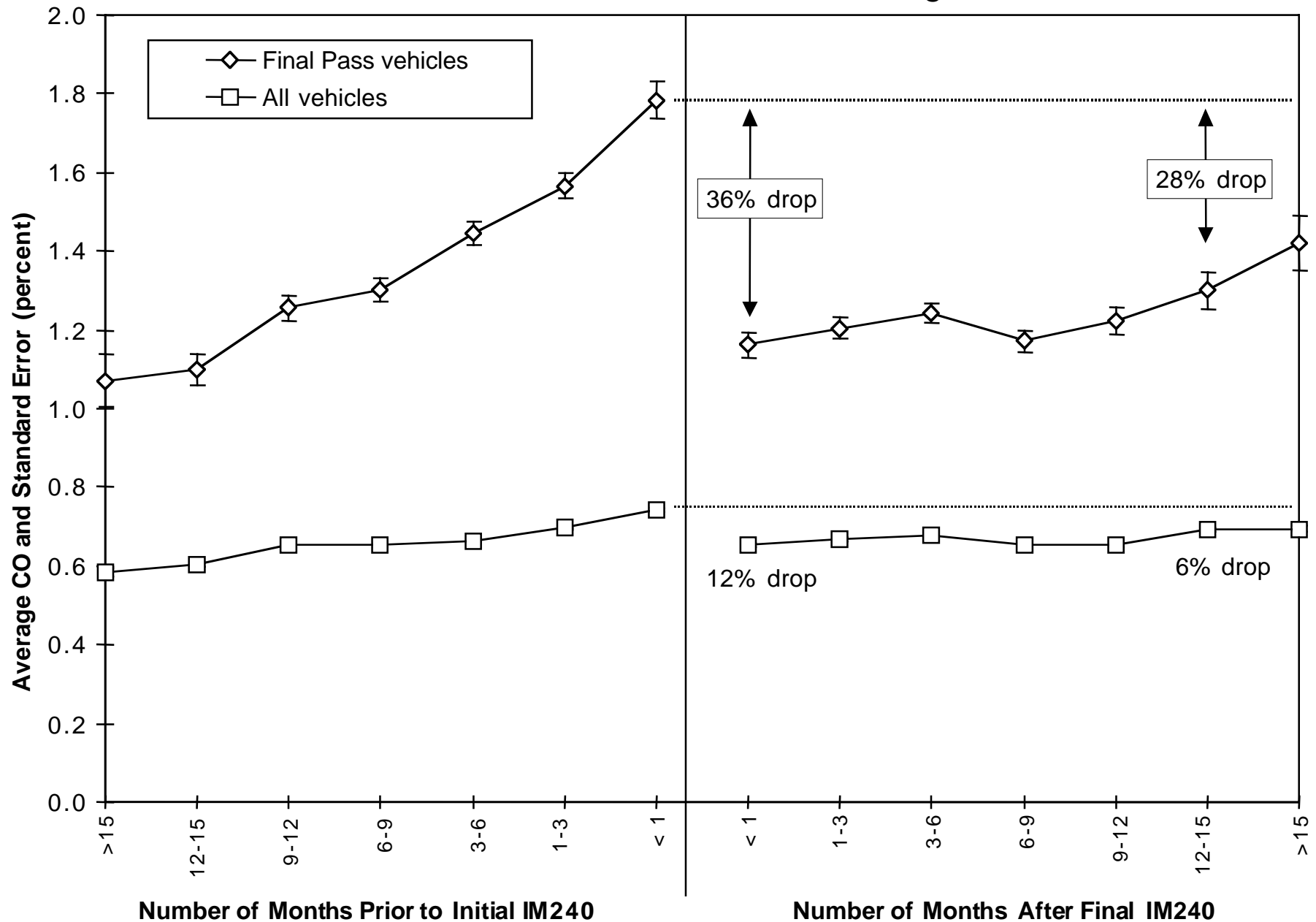
Average RSD CO by MY and I/M Result

Up to 90 days before and after I/M test, 1996-97 Arizona Remote Sensing



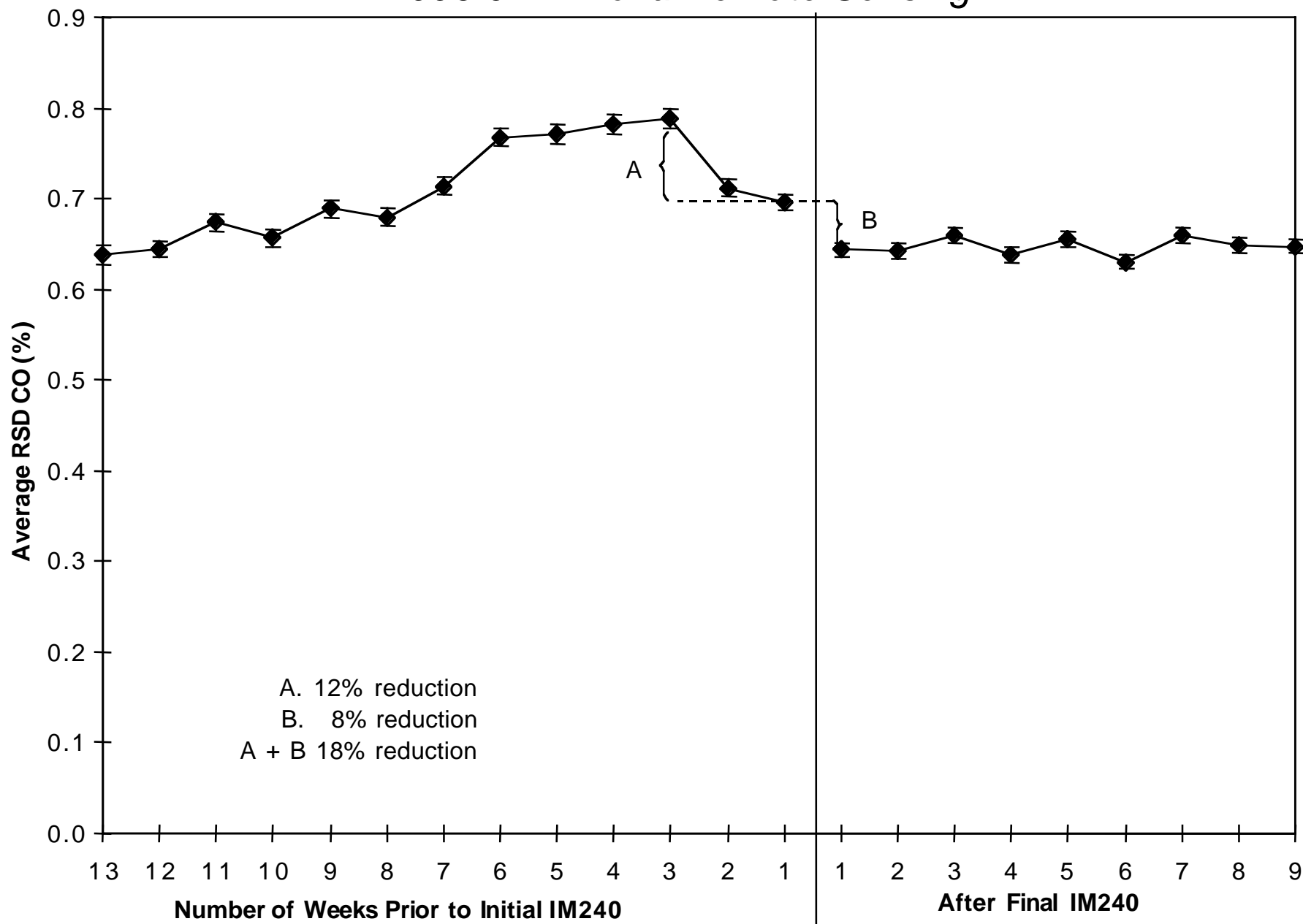
Average CO RSD Emissions by Time Period

1996-97 Arizona Remote Sensing



Average CO RSD Emissions by Time Period

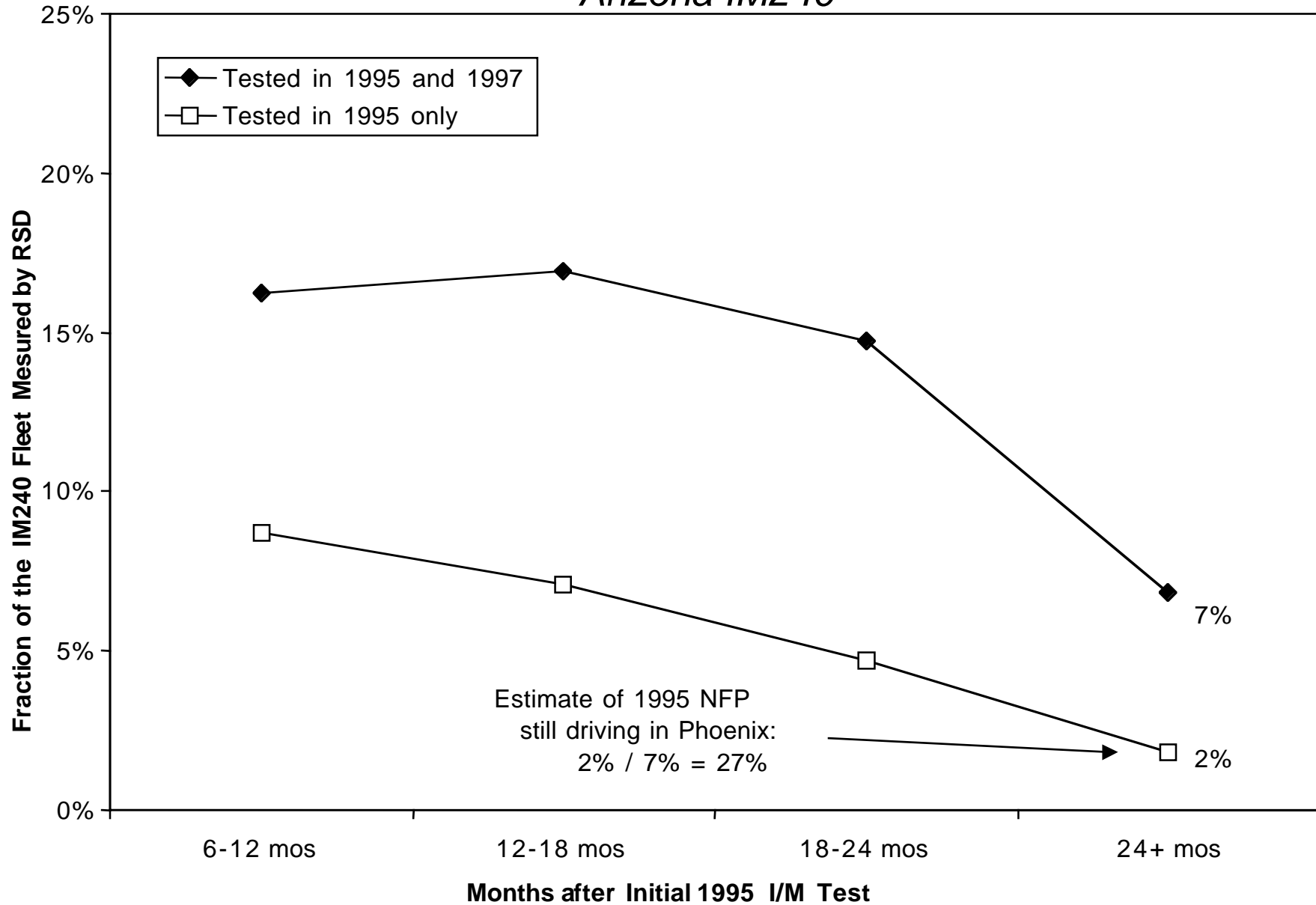
1996-97 Arizona Remote Sensing



Half of No Final Pass Vehicles Remain in I/M Area

- 39% of vehicles failing initial test in 1995 never received a passing test (through March 1996)
- 30% of these reported for testing in 1997
- Of remaining 70%, estimated 27% still driving in area
 - 7% of 1995 No Final Pass vehicles tested in 1997 seen by RSD more than 2 years after 1995 test
 - 2% of 1995 No Final Pass vehicles not tested in 1997 seen by RSD more than 2 years after 1995 test
 - ratio of 2% to 7% = 27%
- Estimated 50% of all 1995 No Final Pass vehicles driven in I/M area
 - 30% reporting for testing, 27% of remainder seen by RSD
(30% + (70% x 27%) = 50%)

Fraction of the 1995 No Final Pass Vehicles
Measured by RSD, by Time
Arizona IM240



Assumptions about No Final Pass Vehicles Affects Evaluation Results

- Has big impact on absolute reduction, small impact on percent reduction
 - assume that program induces No Final Pass vehicles to leave area
 - removing relatively small numbers of vehicles, with high emissions, can have big impact on inventory
- Assume all No Final Pass vehicles continue to drive in area
 - tons per day reduced 11% / 13% / 7%
- Assume all No Final Pass vehicles permanently leave area
 - tons per day reduced 21% / 24% / 13%

Evaluation of Arizona IM240 Program: Summary

- Many vehicles take months to pass, or never pass, I/M test; many of these vehicles still driving in I/M area. Better enforcement needed.
- On average, repairs made to vehicles last about two years. Better repairs needed, or removal of vehicles that repeatedly fail.
- Large reduction in emissions immediately prior to initial I/M test; typically not counted as benefit of program.
- Different analysis methods needed to understand different aspects of I/M programs.

3. Data Improvements to Make Evaluation Easier

- Identify initial I/M test
 - CA: initial test not identified; have to search in previous months for previous failing test
 - AZ: if no pass after 5 months, next test coded initial
- Record VIN and license accurately and consistently
- Record odometer accurately and consistently
- Identify vehicles that receive waiver
- Relatively large (2%) number of full tests random sample of vehicles, to compare with fast pass tests
- Sample of back-to-back full tests to test effect of regression to mean

Program Improvements to Make Evaluation Easier

- I/M cycle should be based on last digit in VIN (AZ), not MY (CO, WI)
- Vehicles should always remain on same I/M cycle, even if sold
- License plates should remain with vehicle (AZ), not original owner (CO), when sold
- AZ is not the “gold standard”
 - fast fails after 90 seconds
 - does not allow second full test for marginal failures
 - CO or WI may be more appropriate?

4. General Evaluation Issues

- What is baseline?
 - no I/M case
 - previous I/M program
 - reference “gold standard” program
- How to measure effectiveness: absolute (average gpm/tons) or relative (%)?
- How to compare emissions in different units (concentrations v. mass)?
 - correlations between small samples of vehicles tested under both methods
 - convert %/ppm to gram per gallon; convert gpg to gram per mile, using mile per gallon assumptions
 - convert %/ppm and gram per mile to gram per gallon

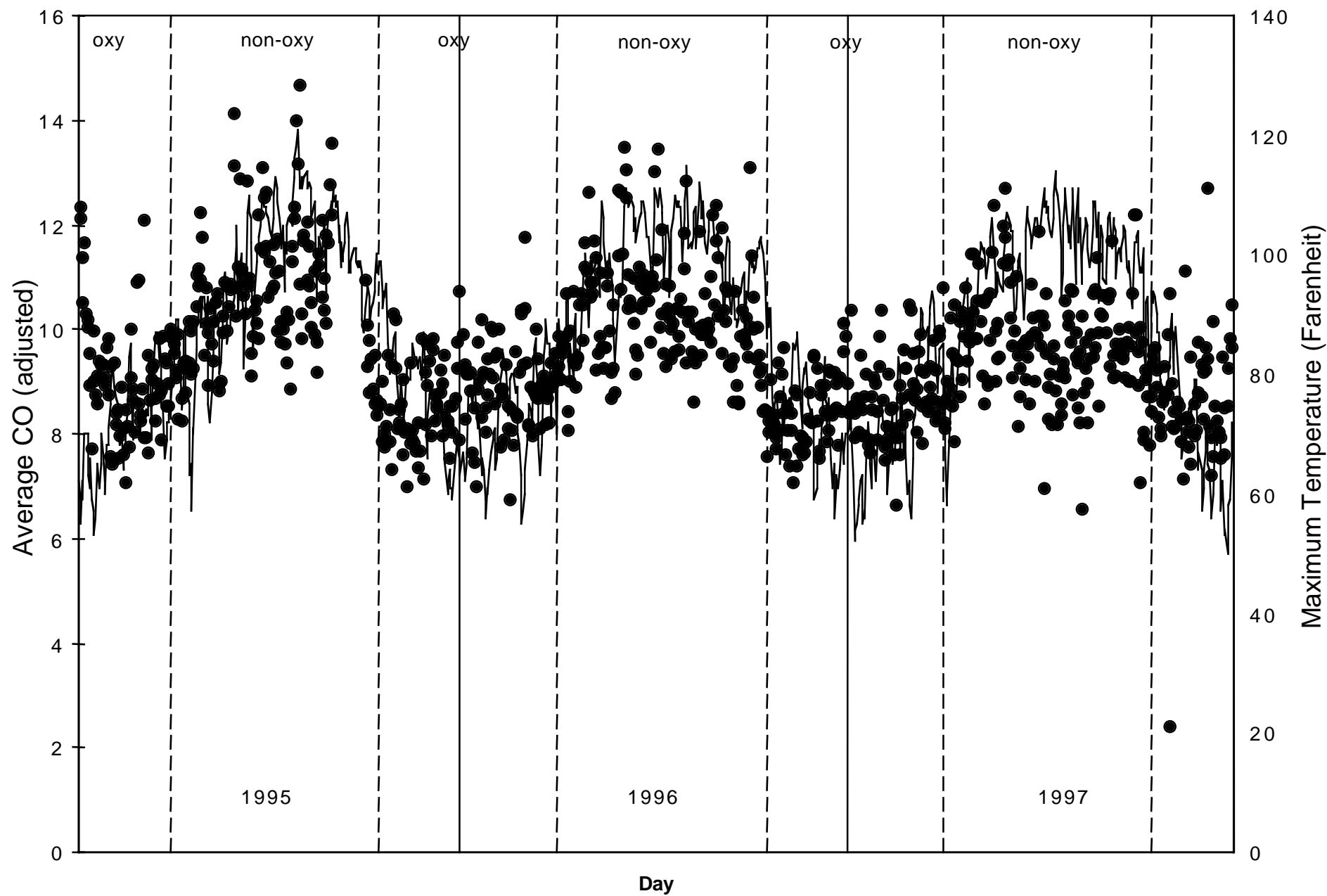
General Evaluation Issues (cont.)

- How to calculate emission reduction?
 - immediately after final test
 - 6 months later
 - 12 months later
- How to treat No Final Pass vehicles?
 - default assumption should be that all NFP remain in area; make states demonstrate otherwise (RSD or video camera surveys)
- Weight results by vehicle or VMT?
 - I/M programs treat all vehicles the same, regardless of use
 - SIP inventories weight vehicles by assumed annual VMT

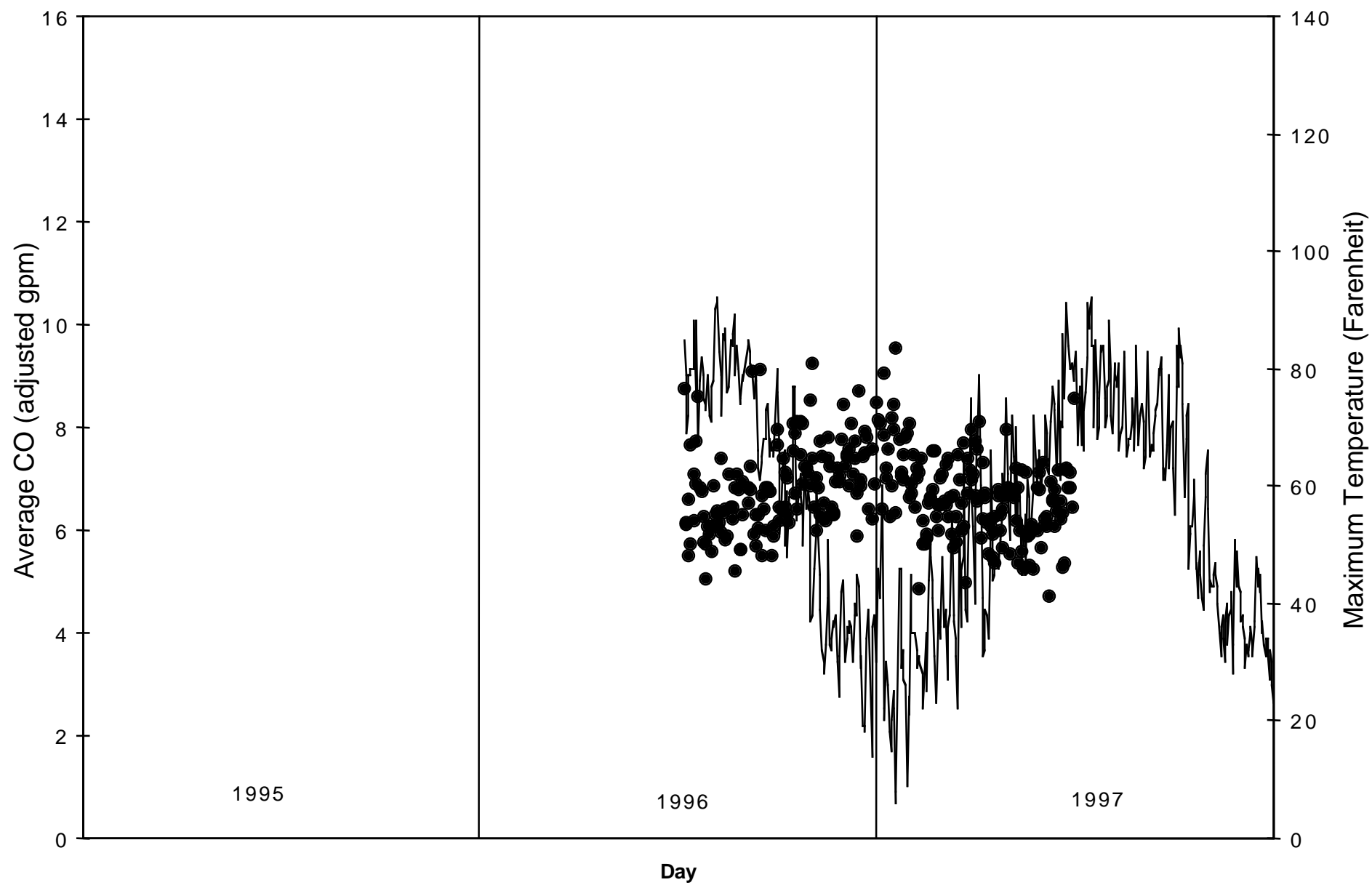
Seasonal Variation in Emissions

- Large seasonal variation in emissions
- AZ and CO IM240
 - HC and CO higher in summer than winter
 - NO higher in winter than summer
- AZ RSD; AZ idle; CA ASM (Sacramento)
 - HC and CO higher in summer than winter
- WI IM240; MN idle
 - HC, CO and NO higher in winter than summer
- Possible causes: combination of temperature, fuel composition changes (oxygenates), and inadequate preconditioning (causing canister purge during test)
- Implications
 - different cutpoints should be applied by season
 - evaluation based on only one or two months of data may be biased

Daily Average CO (adjusted), Initial Tests of Passenger Cars 1995-97 Arizona IM240



Daily Average CO (adjusted), Initial Tests of Passenger Cars 1996-97 Wisconsin IM240



5. CA Enhanced Program

- Enhanced program began in June 98
 - decentralized biennial ASM testing at Test & Repair stations
 - second set of cutpoints for Gross Polluters
 - official pre-test reported but not used for Gross Polluter determination
 - 2% random sample directed to Test Only stations
 - 13% sample of suspected high emitters directed to Test Only stations (using High Emitter Profile)
 - Gold Shield Guaranteed Repair stations identified by BAR
 - Gross Polluters can be certified only by Test Only or certain Gold Shield stations
- Basic and Change of Ownership Only programs continue in some basins
 - decentralized two-speed idle

Evaluation of Enhanced California Program: Data

- CA Enhanced program began in June 98
- Three sets of emissions data
 - Jan 97 to Nov 99 program data (18 mos. enhanced; 10 million vehicles)
 - Feb 97 to Oct 99 random roadside pullover tests (30,000 enhanced vehicles)
 - Jul 99 and Oct/Nov 99 remote sensing measurements (80,000 enhanced vehicles)
- Two “snapshots” of vehicle registration data
 - Apr 98 and Oct 98 (40 million vehicles)

Evaluation of Enhanced California Program: Analysis

- Comparison of initial and final test results in program data
 - effect of pretests on “initial” emissions
 - effect of phasing in NO cutpoints
 - by I/M station type (Test and Repair, Test Only, Gold Shield)
 - by air basin
 - eventually by program type (Basic v. Enhanced)
- Step Method analysis of Roadside and RSD data (Tested under Enhanced v. Not Tested under Enhanced)
- Analysis of new program changes using Roadside data
 - different MY exemptions
 - different cutpoints

6. Different Remote Sensing Evaluation Methods

- Reference Method (Georgia Tech)
 - compare to reference no-I/M case (other urban area)
 - make sure reference area fleet similar to subject area fleet
- Step Method (U Denver)
 - compare tested and untested fleets midway through new I/M program
 - few differences between two fleets
 - measures only incremental benefit of changes to program
- Comprehensive Method (LBNL)
 - Step Method, with many more measurements (millions vs. 50k)
 - track average emissions as vehicles get closer to, and further from, I/M test